ICU
MANAGEMENT & PRACTICE

@ICU_Management

2025
VOLUME 25
ISSUE 4

Science and Research

Using Recovery Rooms (PACUs) Differently: Addressing the Hidden Pandemic, *G Ludbrook, M Grocott, L Tran*

Rethinking Delirium in Critical Care, *M Elkhonezy, H Salem, M Masoud*

Bedside Monitoring of Respiratory Effort in Patients Undergoing Assisted Mechanical Ventilation, *A Caroli, J Nübel, Y Hikasa, N Kitisin, N Raykateeraroj, N Pattamin, G Eastwood, L Peck, H Young, R Bellomo, AS Neto*

Health Information Technology Evaluation: Reimagining Evidence in the Age of Machine Learning and Large Language Models, *V Herasevich, BW Pickering*

Short-Term Capacity Planning in an Intensive Care Unit: Web-Based Prediction Model and Pilot Study, *J Klepstad, P Klepstad*

Nutrition in Critical Care: Evidence-Based Management, *OR Pérez-Nieto, J Beauregard -Mora, CA Galindo-Martín, A Vargas-Torres, A Kammar-García, E Deloya-Tomas*

Electrical Impedance Tomography in Critical Children, *J Trastoy-Quintela, M Pons-Odena, MI Castillejo-San Nicolas, M Ciutad-Celdran, L Hernandez-Platero, I Mata, N Sorolla, I Vicente*

Rapid Blood Pressure Lowering in ICH: Evidence-Based Practice or Persisting Dogma, *R Reyes-Monge, TS Ibarra-Ocegueda, OR Pérez-Nieto, Rodríguez-Guevara, HA Toledo-Palacios, S González–Sotelo*

Establishing an Awake and Walking ICU: Fundamental Concepts and a Case Report, *K Dayton, LAC Batista Filho, H Engel, L Seraphim Cerqueira, L Silva Rodrigues, A Toledo Maciel*

Moral Distress and Heroic Life-Sustaining Treatment: The Mitigating Role of the Patient Perspective, *S Siddiqui, A Milliken*

Future Directions in Critical Care Research: Autophagy and Muscle Hacking, *S Jackson, J Poole*

icu-management.org

INTENSIVE CARE | EMERGENCY MEDICINE | ANAESTHESIOLOGY | CARDIOLOGY | MANAGEMENT | LEADERSHIP

SHOUT
SHARE
IT

Rafael Reyes-Monge
Intensive Care Unit
Hospital General de Uriangato
Guanajuato, Mexico
reyesraphael92@gmail.com

Tonantzin S Ibarra-Ocegueda
Department of Emergency Medicine
Hospital General de Zona No. 83
Morelia, Mexico
tonantzinsol@hotmail.com

Orlando Rubén Pérez-Nieto
Intensive Care Unit
Hospital General San Juan del Rio
Queretaro, Mexico
orlando_rpn@hotmail.com

Ignacio Rodríguez-Guevara
Department of Anesthesiology
Hospital General San Juan del Rio
Queretaro, Mexico
irodriguez20@alumnos.uaq.mx

Rapid Blood Pressure Lowering in ICH: Evidence-Based Practice or Persisting Dogma

This review examines blood pressure management in intracerebral haemorrhage, highlighting the need to prevent haematoma expansion without causing cerebral hypoperfusion. Guidelines recommend early intervention with systolic targets of 130–150 mmHg, avoiding levels below 130 mmHg. The absence of standardised regimens underscores the need for individualised, evidence-based strategies.

Introduction

Intracerebral haemorrhage (ICH) results from the rupture of cerebral blood vessels, leading to bleeding within the brain parenchyma. It is a major cause of mortality and long-term disability, particularly in low- and middle-income countries. According to the 2021 Global Burden of Disease Study, there were approximately 2.44 million new cases of ICH worldwide, with an age-standardised prevalence of 40.8 per 100,000 population. ICH was responsible for an estimated 3.31 million deaths and accounted for 79.46 million disability-adjusted life years (DALYs), with an age-standardised DALY rate of 92.4 per 100,000 population (Xu et al. 2024).

Given this substantial burden, identifying effective strategies to reduce mortality and disability is essential. This review explores the current approach and available evidence regarding the importance of early and aggressive blood pressure reduction in the management of ICH.

Cerebral Autoregulation and Impairment Following Intracerebral Haemorrhage: A Haemodynamic Perspective

Cerebral autoregulation refers to the ability of the cerebral vasculature to maintain relatively stable cerebral blood flow (CBF) despite fluctuations in cerebral perfusion pressure (CPP) (**Figure 1**), typically preserved within a mean arterial pressure (MAP) range of approximately 60 to 150 mmHg in healthy adults (Lassen 1959).

Under physiological conditions, CBF is regulated through dynamic changes in arteriolar diameter, which modulate cerebrovascular resistance (CVR) in accordance with the Hagen–Poiseuille equation, which describes laminar flow of a fluid through a cylindrical tube of constant cross-section:

$$Q = \frac{\pi \cdot r^4 \cdot \Delta P}{8 \cdot \eta \cdot L}$$

In simpler terms, when mean arterial pressure (MAP) decreases, cerebral arterioles vasodilate to increase the radius and preserve flow. Conversely, when MAP rises, arterioles vasoconstrict to reduce the radius and protect the brain from hyperperfusion. However, when MAP falls outside the autoregulatory range, this mechanism fails and CBF becomes passively pressure-dependent, increasing the risk of ischaemia (at low pressures) or cerebral oedema (at high pressures). From a pathophysiological perspective, the Poiseuille equation offers a theoretical framework to understand the alterations in CBF in the setting of impaired autoregulation following ICH. A case-control study comparing patients with acute ICH to healthy controls demonstrated that individuals with ICH had significantly higher cerebrovascular resistance index (CVRi), calculated as the ratio of MAP to mean

Hezael Agustín Toledo-Palacios
Department of Emergency Medicine
Hospital General de Subzona IMSS No. 9
Sonora, Mexico.
hezael12@hotmail.com

Samir González-Sotelo
Department of Emergency Medicine
Hospital General Regional IMSS No. 2
Queretaro, Mexico
d.r.samir@hotmail.com

flow velocity (MFV). This elevation in CVRi reflects increased vascular resistance. Additionally, patients with ICH exhibited higher gain values on transfer function analysis, indicating greater amplitude of flow oscillations in response to pressure changes—a sign of impaired dynamic autoregulation. This contradicts the buffering effect normally exerted by an intact autoregulatory system (Nakagawa et al. 2011). Similarly, a systematic review and meta-analysis including 293 patients with acute ICH assessed physiological disturbances using transcranial Doppler (TCD) ultrasonography. The findings revealed significantly lower mean CBV velocities in both the ipsilateral (49.7 vs. 64.8 cm/s; $p < 0.0001$) and contralateral hemispheres (51.5 vs. 64.8 cm/s; $p = 0.0006$) compared to healthy controls (Minhas et al. 2018) From the perspective of the Poiseuille model, a sustained reduction in arteriolar radius—or failure to adapt this radius in response to pressure changes—could account for the observed hypoperfusion. Therefore, although current guidelines recommend intensive blood pressure lowering in acute ICH, such strategies might worsen cerebral hypoperfusion in regions with impaired autoregulation. Nevertheless, the underlying pathophysiology, including reductions in CBF, does not fully explain observed variations in mortality or neurological outcomes in this patient population, highlighting the need for further targeted research.

Current Guideline Recommendations

According to the current American Heart Association (AHA) guidelines for the management of spontaneous ICH, it is recommended to initiate blood pressure control within the first two hours and to reach the target within the first hour. Early intervention has been associated with a reduced risk of hypertensive oedema. For patients with mild to moderate ICH, maintaining systolic blood pressure between 150 and 220 mm Hg is advised, whereas for severe cases, the target range is 130 to 150 mm Hg. These recommendations are supported by a level of evidence 2b (weak) (Greenberg et al. 2022). However, the 2024 update strengthened the recommendation to level 2a (moderate), reinforcing the importance of early and controlled blood pressure management in patients with ICH (Ruff et al. 2024).

Similarly, the European guidelines align with the American position, recommending systolic blood pressure (SBP) levels between 150 and 220 mmHg, also based on low-quality evidence and a weak recommendation. However, expert opinion suggests maintaining values below 140 mm Hg in the acute phase and avoiding fluctuations in systolic blood pressure. Both the AHA/ASA and European guidelines caution against lowering SBP below 130 mm Hg, as this may be associated with adverse outcomes (Steiner et al. 2025). More recently, a consensus statement from the American Medical Association, the American College of Cardiology, and the AHA proposed a more aggressive approach. These guidelines recommend immediate SBP reduction to 130–140 mmHg in patients presenting with initial values between 150 and 220 mmHg, with maintenance of this target for at least seven days after haemorrhage onset. This strategy has been linked to improved functional outcomes, although blood pressure management should be discontinued if SBP falls below 130 mmHg (Jones et al. 2025). The differences between guideline recommendations are summarised in **Figure 2**, highlighting the therapeutic window that balances the risk of ischemia at lower pressures and oedema at higher pressures.

Evidence on Clinical Outcomes Over the Years

The INTERACT2 trial (Anderson et al. 2013), which enrolled 2839 patients, compared intensive treatment (SBP <140 mmHg, n=1403) with standard treatment (<180 mmHg, n=1436). The primary outcome (modified Rankin Scale [mRs] 3–6 at 90 days) did not significantly differ between groups (52.0% vs. 55.6%; OR 0.87; 95% CI 0.75–1.01; p=0.06), nor did all-cause mortality (11.9% vs. 12.0%; OR 0.99; 95% CI 0.79–1.25; p=0.96). There were no significant differences in early neurological deterioration (14.5% vs. 15.1%; OR 0.95; 95% CI 0.77–1.17; p=0.62) or hematoma expansion (35.1%; p=0.27). However, an ordinal analysis of the mRS suggested improved functional outcomes in the intensive treatment group.

The ATACH-2 trial (Qureshi et al. 2016), which included 1000 patients (mean age 62 years, 60% male), compared intensive SBP lowering (110–139 mmHg, n=500) with standard treatment

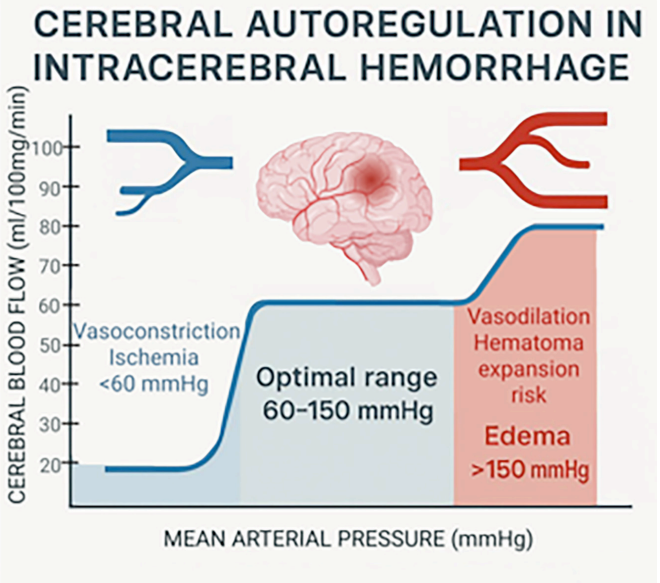

Figure 1. Schematic representation of cerebral autoregulation in intracerebral haemorrhage. Cerebral blood flow is maintained constant within the autoregulatory range of mean arterial pressure (60–150 mmHg) through vasoconstriction and vasodilation. Below this range, hypoperfusion increases the risk of ischaemia, while above it, hyperperfusion predisposes to cerebral oedema.

(140–179 mmHg, n=500) using intravenous nicardipine within 4.5 hours. There was no significant difference in the primary outcome (mRS 4–6 at 90 days: 38.7% vs. 37.7%; p=0.84). Mortality was lower in the intensive group (6.6% vs. 9.0%), but this did not reach statistical significance (p=0.09). Severe hypotension was more frequent in the intensive group (12% vs. 2%), while hematoma expansion occurred in 18.9% compared with controls (p=0.09).

The INTERACT3 trial (Ma et al. 2023), a large multinational stepped-wedge, cluster-randomised trial including 7036 patients from low- and middle-income countries, tested a "care bundle" incorporating intensive SBP control (110–140 mmHg), glucose management, normothermia, and rapid anticoagulation reversal. Compared with usual care (n=3815), the intervention bundle (n=3221) resulted in significant improvement in the primary outcome (ordinal mRS at 6 months; OR 0.86; 95% CI 0.76–0.97; p=0.015). Additionally, early neurological deterioration was significantly reduced (OR 0.56; 95% CI 0.34–0.92; p=0.02), with overall improvement in functional outcomes.

Taken together, the evidence indicates that lowering SBP to around 140 mmHg is safe and may improve functional outcomes, although it does not significantly reduce mortality. The greatest benefit appears to occur when blood pressure management is implemented as part of a multidimensional care bundle, as demonstrated by INTERACT3.

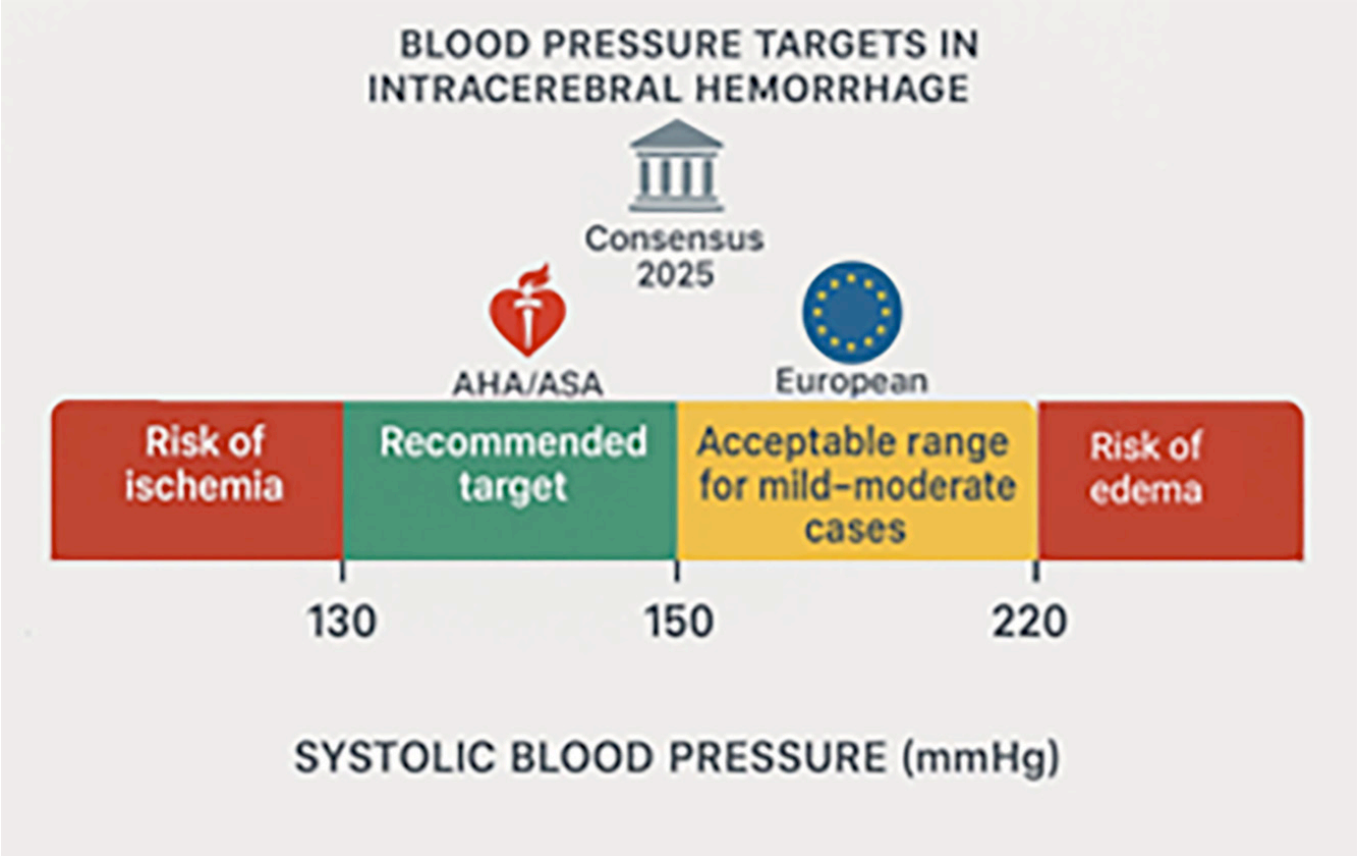

Figure 2. Blood pressure targets in spontaneous intracerebral haemorrhage according to major guidelines. The American Heart Association/American Stroke Association (AHA/ASA) recommends early reduction to 130–150 mmHg, while European guidelines allow systolic pressures between 150–220 mmHg in mild to moderate cases. The 2025 consensus suggests an optimal range of 130–140 mmHg, maintained for at least 7 days. Pressures below 130 mmHg may increase the risk of cerebral ischaemia, whereas values above 220 mmHg are associated with oedema and haematoma expansion.

Limitations of Current Evidence (Drug Heterogeneity)

There is significant heterogeneity in the management of hypertensive emergencies in the context of ICH, as reported in major clinical trials. This variability is largely due to the absence of a standardised protocol identifying the most effective or "safest" antihypertensive agent for blood pressure reduction in ICH.

For instance, in the ATTACH-2 trial, nicardipine was used as the primary intravenous antihypertensive, with additional agents including labetalol, diltiazem, or urapidil (Qureshi et al. 2016). In contrast, the INTERACT3 trial employed a broader range of medications, such as urapidil, nicardipine, sodium nitroprusside, labetalol, and nimodipine (Ma et al. 2023).

Even when considering only these two pivotal studies, the variability in antihypertensive regimens highlights the lack of a universal treatment approach for blood pressure management in ICH.

Recommended Strategies for Rapid Blood Pressure Reduction

A medical treatment strategy based on the implementation of intensive systolic blood pressure reduction to <140 mmHg within one hour—using fast-acting intravenous agents such as urapidil—appears to be the most commonly applied approach in clinical studies. This strategy has shown effectiveness in improving neurological outcomes and reducing mortality in patients with ICH.

Conclusions

The concept of cerebral autoregulation-guided therapy is promising, particularly in the context of individualising CPP or MAP targets for each patient. Nevertheless, definitive evidence demonstrating that direct modulation of autoregulation improves clinical outcomes remains lacking. Current data support rapid systolic blood pressure reduction as the most effective strategy, although further studies are needed to validate and refine this approach.

Standardisation of antihypertensive agents is also essential to facilitate broader applicability of treatment protocols. Based on evidence from INTERACT2, ATACH2, and INTERACT3, we recommend targeting systolic blood pressure within the range of 130–140 mmHg, which appears to provide the best balance between reducing the risk of hematoma expansion and avoiding cerebral hypoperfusion.

Conflict of Interest

None

References

Anderson CS, Heeley E, Huang Y, Wang J, Stapf C, Delcourt C, Lindley R, Robinson T, Lavados P, Neal B, Hata J, Arima H, Parsons M, Li Y, Wang J, Heritier S, Li Q, Woodward M, Simes RJ, Davis SM, et al; INTERACT2 Investigators. Rapid blood-pressure lowering in patients with acute intracerebral hemorrhage. N Engl J Med. 2013;368(25):2355-65.

Greenberg SM, Ziai WC, Cordonnier C, Dowlatshahi D, Francis B, Goldstein JN, Hemphill JC 3rd, Johnson R, Keigher KM, Mack WJ, Mocco J, Newton EJ, Ruff IM, Sansing LH, Schulman S, Selim MH, Sheth KN, Sprigg N, Sunnerhagen KS; American Heart Association/American Stroke Association. 2022 Guideline for the Management of Patients With Spontaneous Intracerebral Hemorrhage: a Guideline From the American Heart Association/American Stroke Association. Stroke. 2022;53(7):e282-e361.

Jones DW, Ferdinand KC, Taler SJ, Johnson HM, Shimbo D, Abdalla M, Altieri MM, Bansal N, Bello NA, Bress AP, Carter J, Cohen JB, Collins KJ, Commodore-Mensah Y, Davis LL, Egan B, Khan SS, Lloyd-Jones DM, Melnyk BM, Mistry EA, Ogunniyi MO, Schott SL, Smith SC Jr, Talbot AW, Vongpatanasin W, Watson KE, Whelton PK, Williamson JD. 2025 AHA/ACC/AANP/AAPA/ABC/ACCP/ACPM/AGS/AMA/ASPC/NMA/PCNA/SGIM Guideline for the Prevention, Detection, Evaluation and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Hypertension. 2025.

Lassen NA. Cerebral blood flow and oxygen consumption in man. Physiol Rev. 1959;39(2):183-238.

Ma L, Hu X, Song L, Chen X, Ouyang M, Billot L, Li Q, Malavera A, Li X, Muñoz-Venturelli P, de Silva A, Thang NH, Wahab KW, Pandian JD, Wasay M, Pontes-Neto OM, Abanto C, Arauz A, Shi H, Tang G, et al; INTERACT3 Investigators. The third Intensive Care Bundle with Blood Pressure Reduction in Acute Cerebral Haemorrhage Trial (INTERACT3): an international, stepped wedge cluster randomised controlled trial. Lancet. 2023;402(10395):27-40.

Minhas JS, Panerai RB, Robinson TG. Feasibility of Improving Cerebral Autoregulation in Acute Intracerebral Hemorrhage (BREATHE-ICH) study: a protocol for an experimental interventional study. BMJ Open. 2018;8(3):e020758.

Nakagawa K, Serrador JM, LaRose SL, Sorond FA. Dynamic cerebral autoregulation after intracerebral hemorrhage: a case-control study. BMC Neurol. 2011;11:108.

Qureshi AI, Palesch YY, Barsan WG, Hanley DF, Hsu CY, Martin RL, Moy CS, Silbergleit R, Steiner T, Suarez JI, Toyoda K, Wang Y, Yamamoto H, Yoon BW; ATACH-2 Trial Investigators and the Neurological Emergency Treatment Trials Network. Intensive blood-pressure lowering in patients with acute cerebral hemorrhage. N Engl J Med. 2016;375(11):1033-43.

Ruff IM, de Havenon A, Bergman DL, Dugue R, Frontera JA, Goldstein JN, Hemphill JC, Marulanda-Londono E, Prabhakaran S, Richards CT, Sunmonu NA, Vilar P, Wolfe SQ. 2024 AHA/ASA Performance and Quality Measures for Spontaneous Intracerebral Hemorrhage: a Report From the American Heart Association/American Stroke Association. Stroke. 2024;55(7):e199-e230.

Steiner T, Purrucker JC, Aguiar de Sousa D, Apostolaki-Hansson T, Beck J, Christensen H, Cordonnier C, Downer MB, Eilertsen H, Gartly R, Gerner ST, Ho L, Holt Jahr S, Klijn CJ, Martinez-Majander N, Orav K, Petersson J, Raabe A, Sandset EC, Schreuder FH, et al; Al-Shahi Salman R. European Stroke Organisation (ESO) and European Association of Neurosurgical Societies (EANS) guideline on stroke due to spontaneous intracerebral haemorrhage. Eur Stroke J. 2025;23969873251340815.

Xu L, Wang Z, Wu W, Li M, Li Q. Global, regional, and national burden of intracerebral hemorrhage and its attributable risk factors from 1990 to 2021: results from the 2021 Global Burden of Disease Study. BMC Public Health. 2024;24(1):2426.

ICU

MANAGEMENT & PRACTICE

icu-management.org @ICU_Management

INTENSIVE CARE | EMERGENCY MEDICINE | ANAESTHESIOLOGY | CARDIOLOGY | MANAGEMENT | LEADERSHIP